Assiut University
Faculty of Science
Physics Department

Exam date 25/8/2019

Quantum Mechanics 411P
Summer 2019
Time allowed: 3Hours

Answer the following question: (*all questions carry the same weight* 10 points)

Question #1

A particle of mass m, which moves freely inside the region $-a \le x \le a$, is initially in the state

$$\psi(x,0)=\frac{1}{\sqrt{5a}}\cos\left(\frac{\pi x}{2a}\right)+\frac{2}{\sqrt{5a}}\sin\left(\frac{\pi x}{a}\right)$$

a) ***Find*** $\psi(x,t)$ at any later time t.

b) ***What*** is the expectation value of the total energy $\langle E\rangle$ for this system?.

Question #2

Consider the wave function $\psi(x,t)=A\,e^{-\lambda|x|}e^{-i\omega t}$

Where A, λ, and ω are positive real constants.

(a) ***Normalize*** ψ

(b) ***Determine*** the expectation values of x and x^2.

(c) ***Find*** the standard deviation of x. ***Sketch*** the graph of $|\psi|^2$, as a function of x.

Question #3

From separation of variables applied to the time-independent Schrödinger equation, we have:

$$\frac{1}{R(r)}\frac{d^2}{dr^2}\left(r^2\frac{dR(r)}{dr}\right)-\frac{2mr^2}{\hbar^2}\left[V(r)-E\right]=\ell(\ell+1)$$

for integer ℓ. ***Transform*** to the new function $u(r)=r\,R(r)$, and ***show*** that the above can be written as:

$$-\frac{\hbar^2}{2m}\frac{d^2u(r)}{dr^2}+\left[V(r)+\frac{\hbar^2}{2m}\frac{\ell(\ell+1)}{r^2}\right]u(r)=E\,u(r).$$

Question #4

Work out the radial wave functions $R_{30}(r)$ and ***normalize*** it.

Question #5

Show that for Hydrogen-like atom $<r>=\frac{3a_o}{2Z}$ for the ground state , and ***show that***

$r_{mp}=\frac{a_o}{Z}$ for the ground state.

$$\left(\psi_{1s}=\frac{1}{\sqrt{\pi}}\left(\frac{Z}{a_o}\right)^{3/2}e^{-Zr/a_o}\right)$$

***** ***** ***** ***** ***** ***** **Good Luck** *** ***** ***** ***** ***** *****

Prof. Dr. A. A. Ebrahim

جامعة أسيوط　　امتحان الفصل الدراسي الصيفي / أغسطس 2019　　الزمن : ساعتان

كلية العلوم　　الفرقة الثالثة والرابعة علوم فيزياء

قسم الفيزياء　　فيزياء فلكية (381ف)　　التاريخ الاثنين 2019/9/2

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أجب عن الأسئلة الآتية (الدرجات متساوية) :

1 – (أ) اذكر فقط قوانين كيبلر مع كتابة الصيغة الرياضية لكل منها

(ب) احسب نسبة التغير في الضغط عند قمة جبل ($h = 13700\ feet$) حيث $H_{eff} = 33000\ feet$

2 – (أ) اشرح مفهوم وحدات القياس الفلكية وما هي العلاقة بينها

(ب) اشرح المقصود بكل من (سرعة الهروب – الإزاحة الحمراء – حزامي فان ألن)

3 – (أ) اشرح باختصار الخصائص العامة للكواكب

(ب) حول الأحداث التالية للتقويم الهجري (يوم ميلادك – بداية القرن الحادي والعشرين – نشأة جامعة أسيوط أكتوبر 1957م)

4 – (أ) أذكر ما تعرفه عن :الاعتدالين والانقلابين – الرياح والعواصف الشمسية.

(ب) اشرح اثنين فقط : الثقب الأسود – عدسة الجاذبية – الكواكب بين النجمية – السديم الكوني

5 – (أ) اذا كانت السنة على الكواكب التالية مقدرة باليوم الشمسي تعـــادل **Mercury (88 days)** **Saturn (29 years)** **Earth (365 days)** فاحسب مستخدما قاعدة بودا سرعة دوران كل منها حول الشمس وسرعة دوران الأرض حول نفسها علما (**$AU=1.49x10^{11}m$, R $6.37x10^{6}m$**)

(ب) اشرح المقصود بكل من (الكسوف والخسوف – المد والجزر – حلقات زحل)

. *******انتهت الأسئلة*مع أطيب التمنيات*** ا.د. جلال سعد ********

Assiut University	Final Exam	Semester: Summer 2019
Faculty of Science	Physics of Semiconductors and Thin	Date: 28-08-2019
Physics Department	Films and its Applications (P451)	Time allowed: 3 hours

INSTRUCTIONS TO STUDENTS

1. This assessment paper contains **SIX (6)** questions and comprises **NINE (9)** printed pages.
2. Students are required to answer **FIVE (5)** questions only.
3. Students should write the answer for each question on a new page.
4. This is a **CLOSED BOOK** assessment.
5. A table of physical constants is at the end of the assessment paper in annex A.
6. Permitted materials: electronic calculators.

Question One (10 Marks Total)

(a) Briefly discuss the temperature dependence of semiconductor conductivity?

(6 Marks)

(b) Define:

(i)Diffusion length.

(ii)Lifetime of minority carriers.

(ii)Fermi energy.

(iv)Schottky barrier height.

(4 Marks)

Question Two (10 Marks Total)

(a) An n-type silicon has been doped uniformly with 10^{16} antimony (Sb) atoms.cm^{-3}. Calculate the position of the fermi energy with respect to the fermi energy level in intrinsic Si. This n-type Si sample is further doped with 2 x 10^{17} boron atoms.cm^{-3}. Calculate the position of the fermi energy with respect to the fermi energy level in intrinsic Si. Assuming T = 300 K, and n_i = 1 x 10^{10} cm^{-3}. **(6 Marks)**

(b) In short paragraph with sketch, show how you can engineer the fermi energy level of semiconductor? **(4 Marks)**

Question Three (10 Marks Total)

(a) What is a degenerate semiconductor?

(3 Marks)

(b) Draw the band structure of a degenerate semiconductor?

(3 Marks)

(c) Using the band diagram show how we can use the ohmic contact principle in cooling system?

(4 Marks)

Question Four (10 Marks Total)

(a) What is the Schottky diode? Draw the band structure of Schottky diode at equilibrium?

(3 Marks)

(b) Consider a n-type Si sample doped with 10^{16} donors.cm^{-3} at 300K.

(i) Given the effective mass of the electrons are approximately 1.08me. what is the effective density of states at conduction band edge? **(2 Marks)**

(ii) The electron affinity (χ) of this Si is 4.01 eV and the work function, Φ, of four potential metals for the two ends contacts are listed in table 1 below. Ideally which metal will result in a Schottky contact and which metals will result in an ohmic contact? Justify your answer.

(5 Marks)

Table 1	**Work Function in (eV)**		
Cs	Li	Al	Au
1.8	2.5	4.25	5.0

Question Five (10 Marks Total)

(a) With sketch, what is the direct and indirect Bandgap Semiconductors?

(3 Marks)

(b) An abrupt Si $p^{+}n$ junction diode has a cross sectional area of 1 mm^2, an acceptor concentration of 5 x 10^{18} boron atoms.cm^{-3} on the *p*-side and a donor concentration of 10^{16} arsenic atoms.cm^{-3} on the *n*-side. The lifetime of holes in the *n*-region is 417 ns, whereas that of electrons in the *p*-region is 5 ns due to a greater concentration of impurities (recombination centers) on that side. Mean thermal generation lifetime is about 1 μs. The lengths of the *p*-and *n*-regions are 5 and 100 microns respectively. (ε = 11.9, n_i = 1 x 10^{10} cm^{-3}).

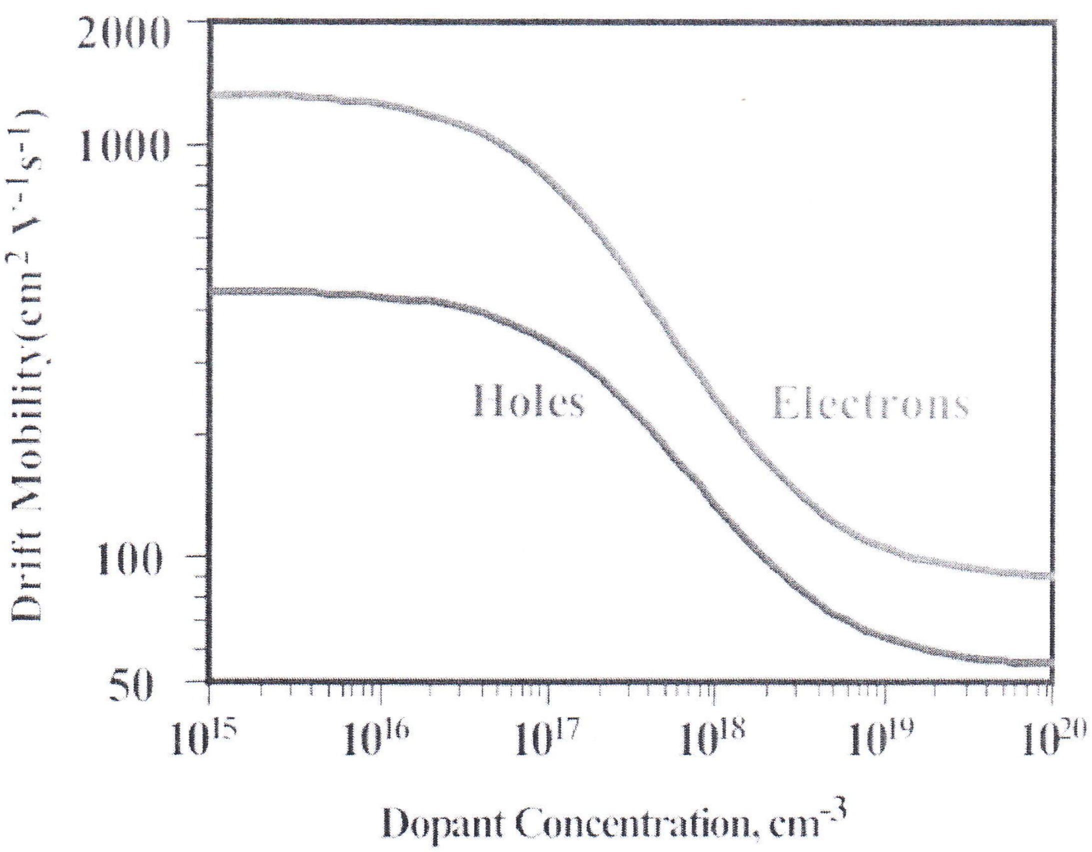
(i) Calculate the minority diffusion length and determine what type of diode this is.

(ii) What is the built-in potential across the junction?

(iii) What is the current when there is a forward bias of 0.6 V across the diode at 27 °C? Assume that the current is by minority carrier diffusion

(iv) What is the reverse current when the diode is reverse-biased by a voltage V_r = 5 V?

(7 Marks)


2000
1000
100
50
Drift Mobility(cm² V⁻¹s⁻¹)
Holes
Electrons
10^15
10^16
10^17
10^18
10^19
10^20
Dopant Concentration, cm⁻³

Question Six (10 Marks Total)

(a) With comment, Draw the band diagram for a *pn* junction under open circuit, forward bias, reverse bias, and thermal generation conditions

(6 Marks)

(b) With sketch, what is the direct and indirect recombination?

(4 Marks)

With my Best wishes

Dr Abdelnaby M Elshahawy

Annex A

Table of Physical Constants

Symbol	Name	SI
c	Velocity of light in vacuum	2.998×10^{8} ms^{-1}
H	Planck's constant	6.626×10^{-34} J.s
N_0	Avogadro's number	6.022×10^{26} $(kg\ mol)^{-1}$
ε_0	Permittivity of vacuum	$8,854 \times 10^{-12}$ $F.m^{-1}$
μ_0	Permeability of vacuum	$4\pi \times 10^{-7}$ $H.m^{-1}$
R	Gas constant	8.317×10^{3} $J\ (kg\ mol.K)^{-1}$
F	Faraday	9.65×10^{7} $C(kg\ mol)^{-1}$
e	Electronic charge	1.602×10^{-19} C
m_e	Electronic rest mass	9.109×10^{-31} kg
e/m	Specific electronic charge	1.759×10^{11} $C.kg^{-1}$
λ_c	Compton wavelength of electron $\left(\frac{h}{mc}\right)$	2.426×10^{-12} m
r_e	Classical radius of electron	2.818×10^{-15} m
m_p	Proton rest mass	1.672×10^{-27} kg
m_n	Neutron rest mass	1.675×10^{-27} kg
K	Boltzmann constant	1.381×10^{-23} $J.K^{-1}$
σ	Stefan-Boltzmann constant	5.67×10^{-8} $J\ (m^2.K^4.s)^{-1}$
V_0	Standard volume of ideal gas	22.42 $m^3\ (kg\ mol)^{-1}$
μ_B	Bohr magneton	9.27×10^{-24} $J.m^2.Wb^{-1}$
μ_N	Nuclear magneton	5.05×10^{-27} $J.m^2.Wb^{-1}$
μ_P	Proton magnetic moment	$2.7928\mu_N$
μ_n	Neutron magnetic moment	$-1.9131\mu_N$
E_0	Energy associated with 1eV	1.602×10^{-19} J
	Atomic mass unit	1.6603×10^{-27} kg
α	Fine structure constant	7.297×10^{-3}
a_0	First Bohr radius	5.292×10^{-11} m
T_0	Absolute temperature of ice-point	273.15 K
g	Acceleration due to gravity (Singapore)	9.7805 ms^{-2}